Short Course on Experimental Dynamic Substructuring

Module #6: Exercises and Application to Guitar System

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Short Course Notes For:
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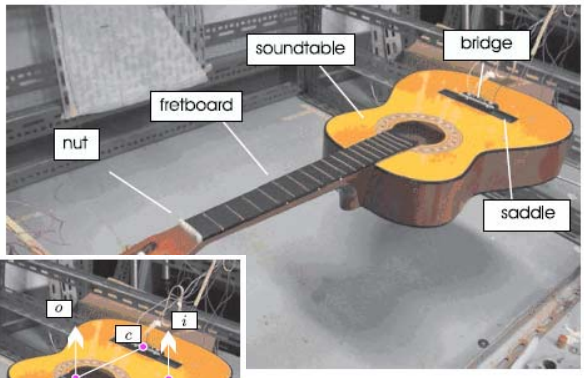
References / Sources

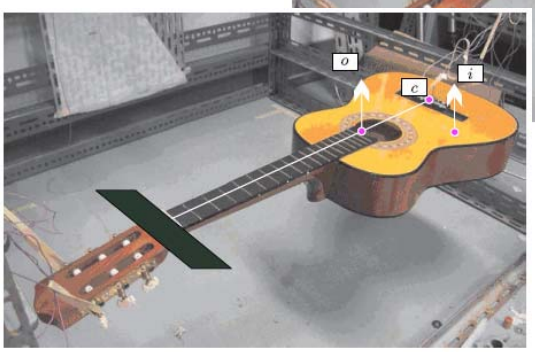
- The example presented here is adapted from the following:
  - D. J. Rixen, T. Godeby, and E. Pagnacco, "Dual Assembly of substructures and the FBS Method: Application to the Dynamic Testing of a Guitar," in *International Conference on Noise and Vibration Engineering: ISMA* Lueven, Belgium, 2006

Abstract
Dynamic substructuring techniques allow to assemble the dynamic response measured for subcomponents (in terms of frequency response function) and to build the experimental dynamic model for the complete system. The most straightforward and commonly used approach is the Frequency Based Substructuring techniques. Although the theory underlying the method is well understood, experimental substructuring techniques usually fail to provide accurate global models due for instance to the high sensitivity of the accuracy of the model to measurement errors and to the difficulty in measuring rotational degrees of freedom on the interfaces. In this paper we will show that, at least for simple structures, the Frequency Based Substructuring approach leads to accurate models if clean measurements are done. Also we discuss the case study of a substructuring exercise performed on a guitar that allowed to better understand the interaction between the wooden instrument (body and fret board) and the strings.

Experimental Application

- Find $H_{i,o}$ for: analytical string + experimental measurements of guitar body.



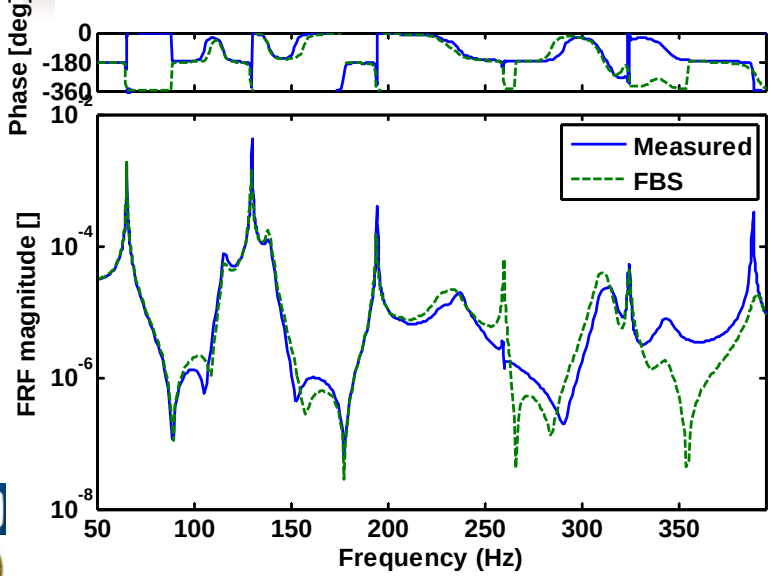


Exercise

- The m-file “Guitar_Example.m” will load the FRFs for:
  - Substructure 1: The Guitar Body
  - Substructure 2: The String (generated analytically)
- Your mission is to compute the response of the assembled system and compare it to a measurement.
  - If time allows you can substitute your own measurements for the guitar body and re-compute the response of the assembly.
  - The FRFs of the string can be re-generated for different values of the tension.

Stop here until you are done with the exercise!

Solution with the Measurements Provided

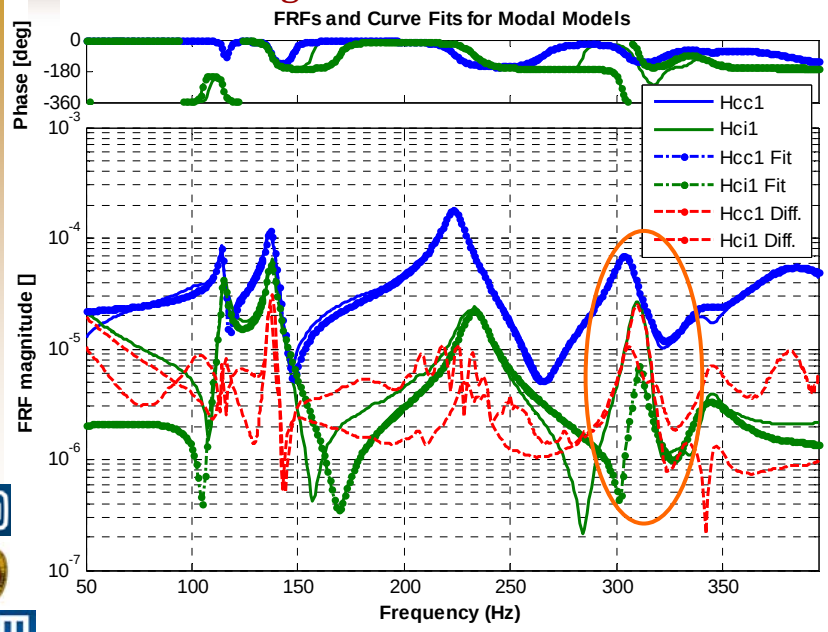


- FBS results are reasonable out to 300 Hz or so.

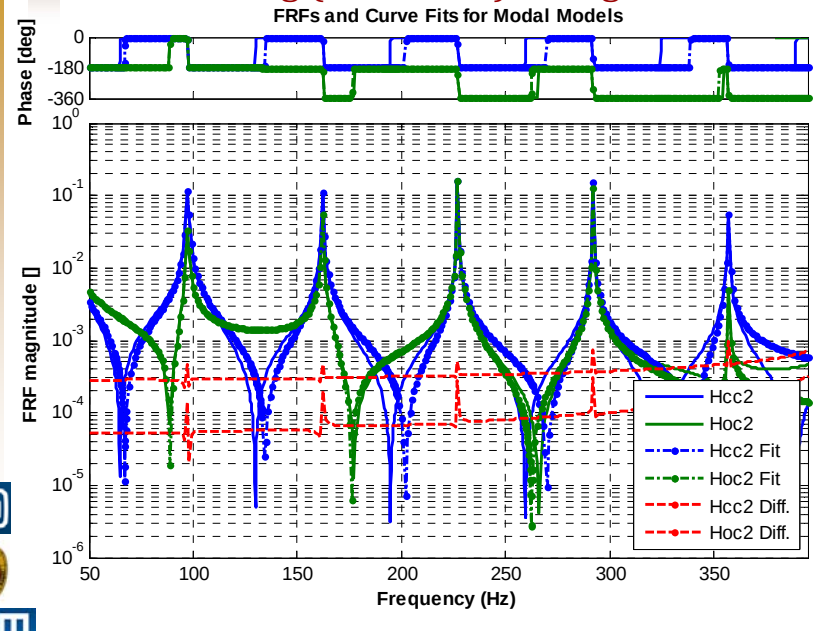
The example illustrates many of the key issues encountered when performing substructuring:

- Modal and Frequency Based Substructuring give essentially identical results when operating on identical data.
- Modes must be extracted in order to perform MS
  - Can be difficult for some systems!
  - May lead to important insights or allow a more robust treatment of nonlinearity. (Phase issues, nonlinearity, etc…)
- Out of band effects:
  - Automatically included with FBS (if a complete set of measurements was obtained)
  - Require extra effort when curve fitting prior to MS
- Modal Substructuring produces a compact set of modal parameters to describe the assembly.

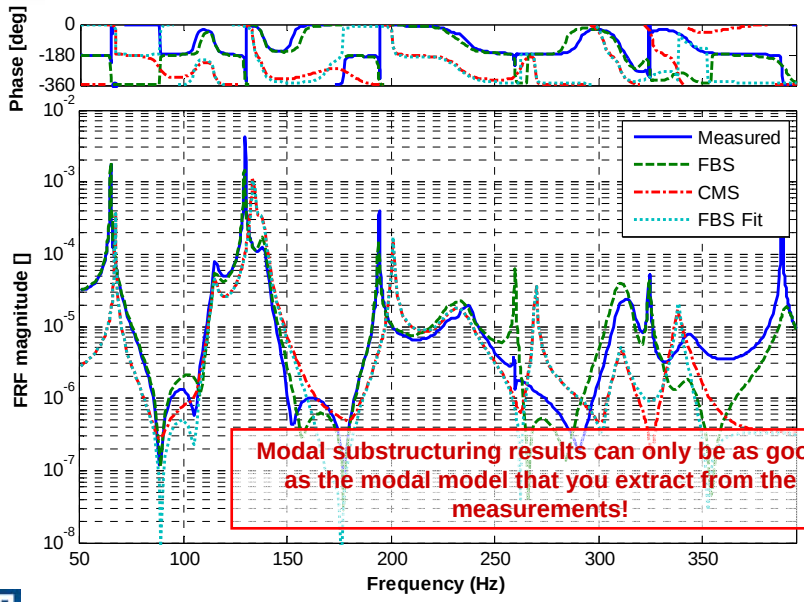
Curve Fitting Guitar Measurements:



Curve Fitting (simulated) String FRFs

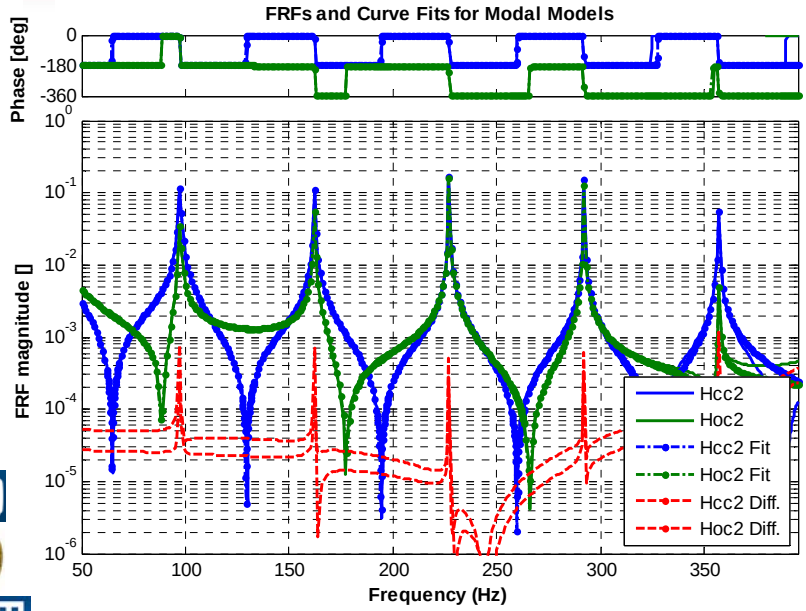


Substructuring Results Hoi(ω)



Modal substructuring results can only be as good as the modal model that you extract from the measurements!

Improved Curve Fit



Substructuring Results with Improved String Model